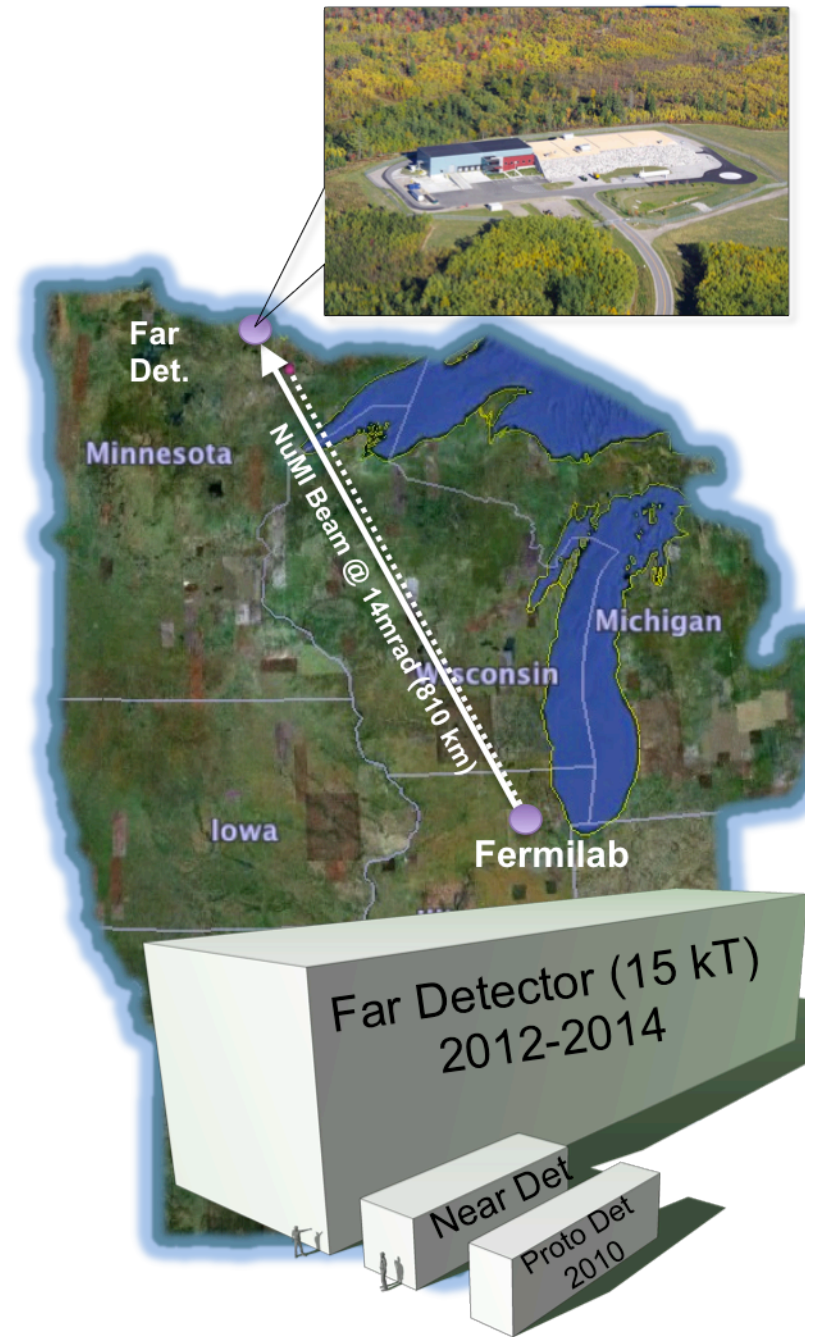




NOvA Projects

SCD Cross-Division
Projects Meeting
29AUG2012





NOvA Computing

- A general NOvA overview and the SCD involvement in NOvA and NOvA computing has been drafted and published in sharepoint

See:

<https://sharepoint.fnal.gov/cs/Pages/ComputingAtFermilab/NOvA-Computing.aspx>



NOvA Sharepoint

Computing at Fermilab

- Computing Policies
- Computer Security
- Computing Services
- Scientific Computing
- Cutting Edge Computing

Organizations

- Computing Sector
- Accelerator Division IT

NOvA is uniquely positioned to significantly contribute to our knowledge sector due to the surprisingly large value of θ_{13} that has recently been measured by Daya Bay, Reno and Double Chooz collaborations. NOvA was specifically designed to make measurements of electron neutrino appearance and the large in large event rates in both the neutrino and anti-neutrino running conditions. Combining these results, NOvA will measure the position in the neutrino oscillation plane which can be directly compared to the theoretical predictions for normal and inverted mass hierarchies, as parameterized in the CP violating phase δ . NOvA allows NOvA to simultaneously access both the mass ordering of the neutrinos and the probe for CP violation over a large region of the allowed phase space.

In addition, NOvA will make higher precision measurements of the θ_{23} neutrino mass hierarchy and anti-neutrinos. This level of precision will allow NOvA to probe θ_{23} is non-maximal. If θ_{23}

is non-maximal then NOvA will also be able to probe the octant to which ν_3 couples more strongly to the muon or tau flavored neutrino sector.

Beyond measuring the fundamental properties of neutrino mixing, NOvA will search for new physics. One of the most exciting is the prospect for NOvA being able to search for sterile neutrinos. The neutrinos from supernova have the potential to expand our understanding of the universe.

The full NOvA technical design report is available at [Nova Technical Design Report](#).

Detector Construction



The NOvA experiment is currently constructing the far detector. The detector was intended to bring together all the technical aspects of the NOvA detection and readout systems to demonstrate their ability to meet the technical specifications of the experiment. The near detector prototype has been used extensively to improve the designs of individual parts of the detector and to collect valuable data that is being used to develop reconstruction and analysis algorithms for the far detector.

The NOvA experiment began construction of the far detector in the Summer of 2012. This gigantic 14 kton detector will begin taking physics data in May 2013 when the upgrades to the NuMI beam lines have been completed. Initially the data taking will start with approximately the first 1/3rd of the detector mass fully operational, but will quickly ramp up to the full detector size over the course of 2013. The full detector will be completed in the spring of 2014 and is scheduled to take data into the next decade.

For more information on the far detector and to see live photos of the far detector constructions go to: [NOvA at Work](#) and [Nova Far Detector Cameras](#)

NOvA Computing

The NOvA experiment relies heavily on state of the art electronics and high speed computing to gather, filter and analyze the data from the near and far detectors. The electronics and computing infrastructure for NOvA broadly falls into general categories relating to online data acquisition, monitoring, remote operations of the detectors, data management, data cataloging and offline analysis. Each of these categories has involved extensive design and development work by the Fermilab computing sector working in collaboration with the NOvA project and its collaborating institutions.

NOvA DAQ Readout System

The NOvA Data Acquisition system was designed to continuously readout and process more than 368,000

Computing > NOvA Computing

NOvA Overview & Physics

The NOvA experiment is a new long baseline neutrino experiment designed to make precision measurements of electron neutrino and anti-neutrino appearance and muon neutrino and anti-neutrino disappearance in the NuMI beam. These measurements will allow NOvA to probe and potentially resolve the neutrino mass hierarchy and search for CP violation in the neutrino sector.

The experiment uses a combination of two detectors, a small "near detector" located at Fermilab which measures the initial composition of the beam and an enormous 14 kton "far detector" which is used to detect and measure the properties of the neutrino after they have traveled through 503 miles of the earth's crust on their way from Fermilab to Ash River Minnesota. The comparison of the rates of neutrino interactions between the two detector sites forms the core of the measurements that NOvA makes and allows the experiment to examine the structure of the neutrino sector.



NOvA

detector are combined, they represent a system that is capable

systems with the beam spills occurring at Fermilab is a custom designed, GPS based system that was developed by the NOvA team to provide a universal time stamp and clock to every electronic "wall time" to every hit that occurs on the NOvA detector and are same neutrinos.



neutrinos in the DAQ readout chain, so that they all have exactly the same time stamp. An advanced loop back scheme where the exact propagation delays are calculated from this information and used to correct the readout hardware receives the marker at exactly the



The core components of the NOvA timing system were deployed to Ash River in the winter of 2012 and have been used to characterize the stability and performance of the system. The full timing system was deployed to the far detector in the summer of 2012 and has been used to demonstrate the capability to synchronize the system in such a way that unit to unit variation is well within the technical specifications with a measured value of less than 8ns.

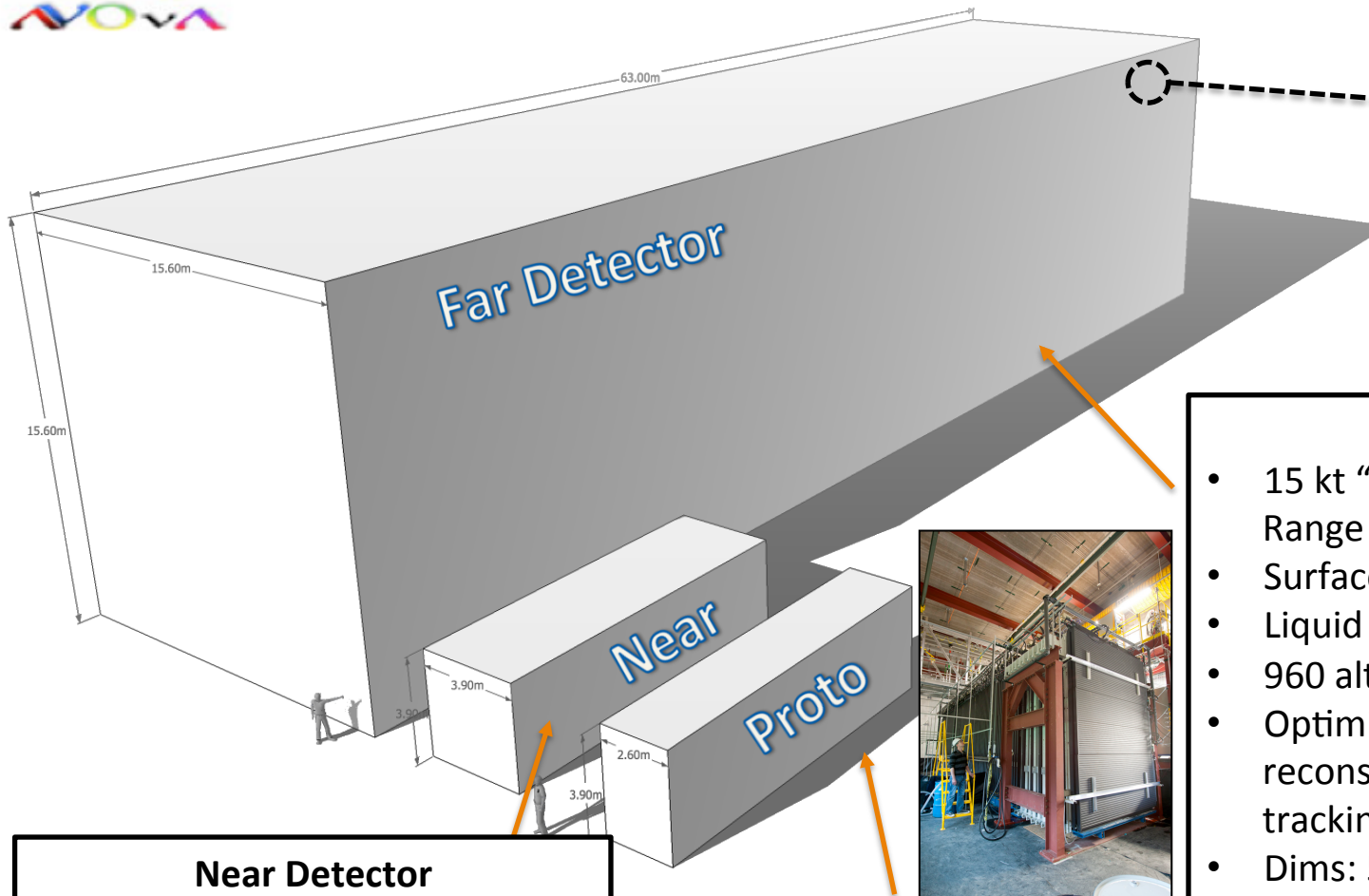
DAQ Software System

The NOvA DAQ system uses not only custom electronics, but a large suite of custom software that is responsible for interacting with the readout hardware and performing high speed event building and filtering. The software has been designed to run directly on the data concentrator modules under a custom build embedded Linux operating system that has been optimized for the PowerPC platform. This software is capable of assembling the input data streams from the 2048 channel region of the detector and repackaging it into well defined, time ordered, 5ms time windows of data which can then be broadcast over standard Ethernet to a large computing farm that is housed at the far detector site.





NOvA Detectors



Near Detector

Identical to far detector
1:4 scale size
Underground Detector
Optimized for NuMI cavern rates
-- 4x sampling rate electronics

Near Det. Prototype

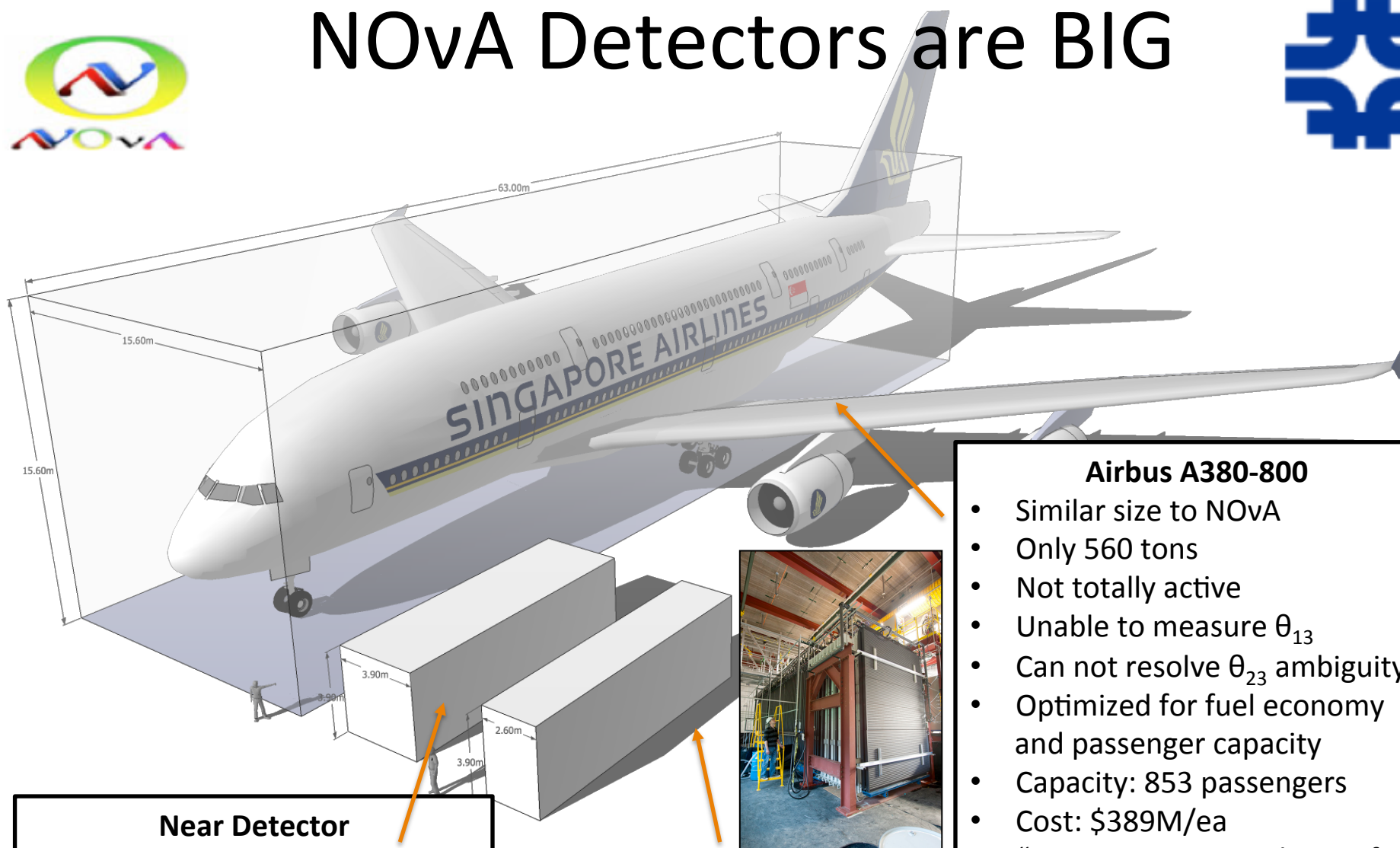
In operation 2010-Present on
surface at FNAL in NuMI and
Booster beam line

Far Detector

- 15 kt “Totally Active”, Low Z, Range Stack/Calorimeter
- Surface Detector
- Liquid Scintillator filled PVC
- 960 alternating X-Y planes
- Optimized for EM shower reconstruction & muon tracking, $X_0 \approx 40\text{cm}$, $R_m \approx 11\text{cm}$
- Dims: 53x53x180 ft
- “Largest Plastic Structure built by man”
- Began construction May 2012
- First operation est. Sep. 2012 (cosmics)



NOvA Detectors are BIG



Near Detector

Identical to far detector
1:4 scale size
Underground Detector
Optimized for NuMI cavern rates
-- 4x sampling rate electronics

Near Det. Prototype

In operation 2010-Present on
surface at FNAL in NuMI and
Booster beam line

Airbus A380-800

- Similar size to NOvA
- Only 560 tons
- Not totally active
- Unable to measure θ_{13}
- Can not resolve θ_{23} ambiguity
- Optimized for fuel economy and passenger capacity
- Capacity: 853 passengers
- Cost: \$389M/ea
- "Largest commercial aircraft built by man"
- Construction start 2004
- First operation Oct. 2007 (Singapore Airlines)

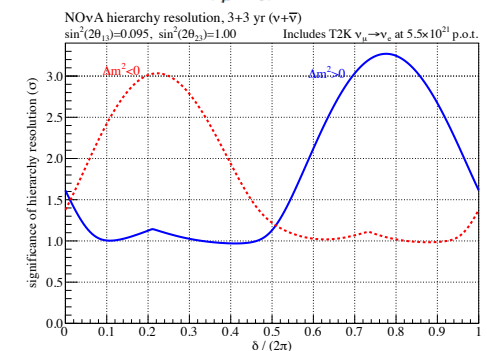
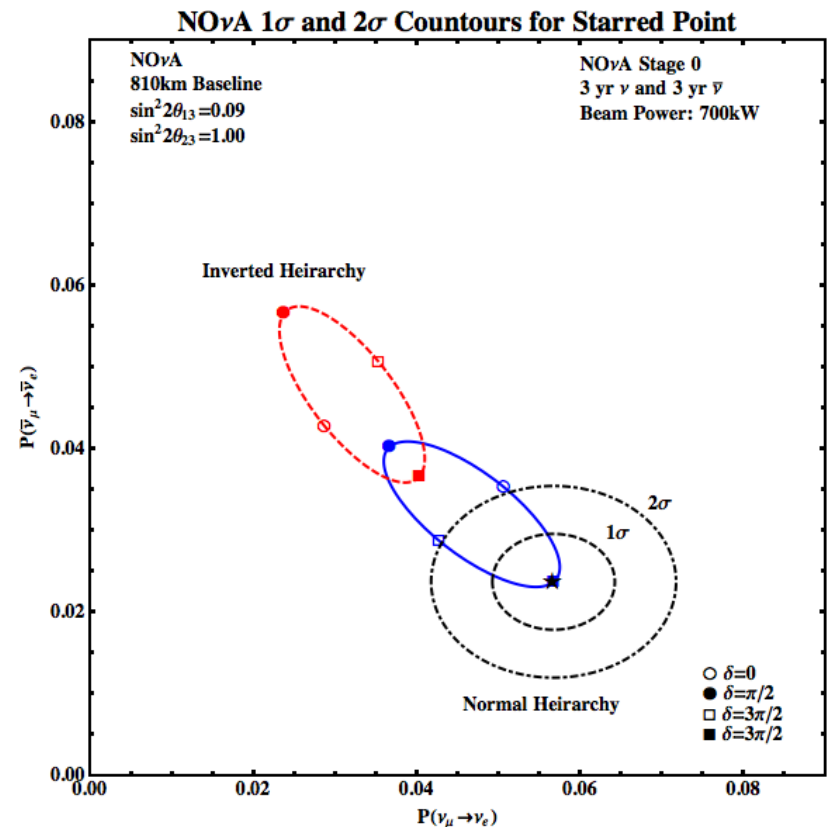


NOvA Overview

- Scientific Goals:
 - Perform precision measurements of the appearance & disappearance channels:

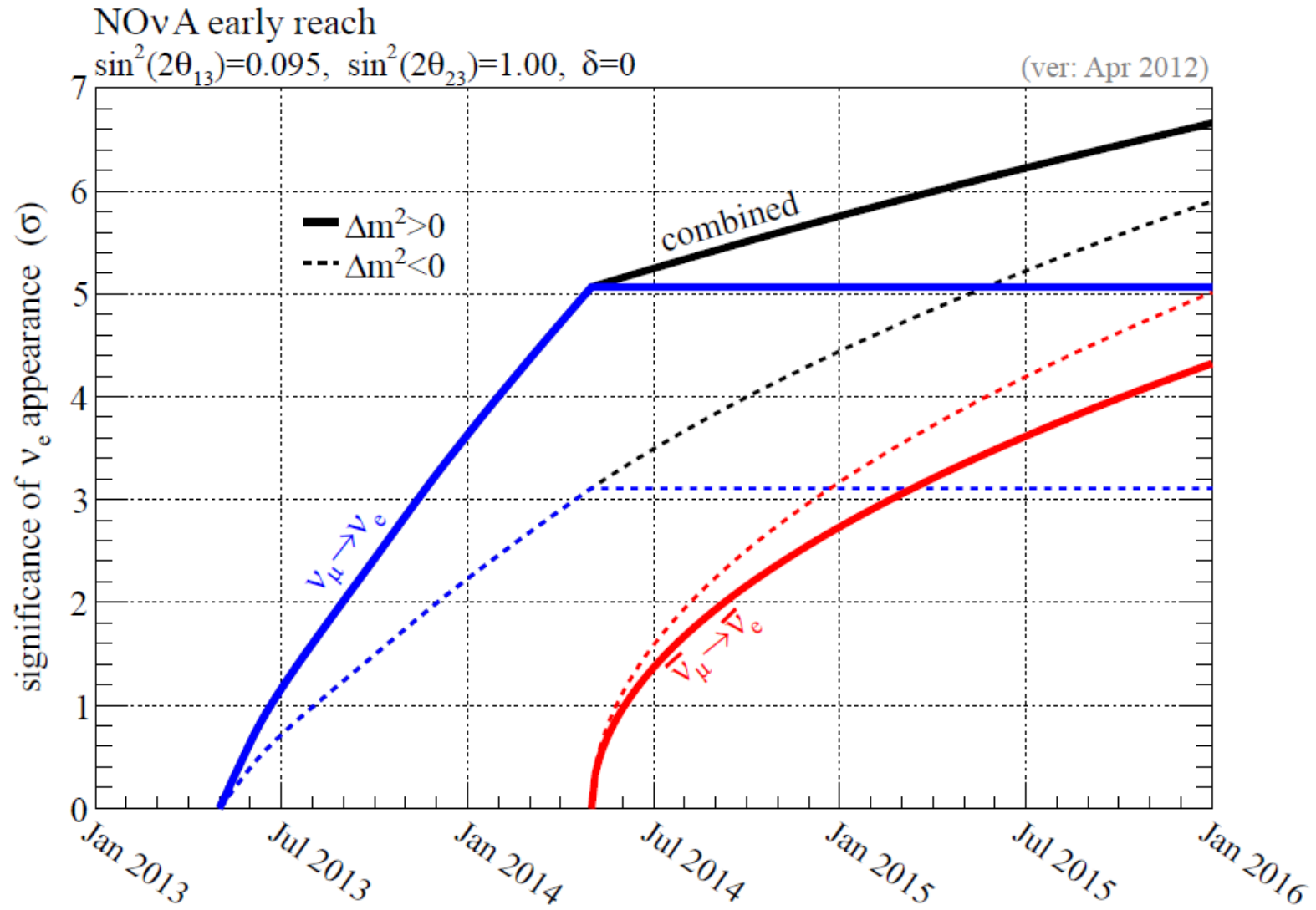
$$P(\nu_\mu \rightarrow \nu_e) \quad P(\bar{\nu}_e \rightarrow \bar{\nu}_\mu)$$

$$P(\nu_\mu \rightarrow \nu_\mu) \quad P(\bar{\nu}_\nu \rightarrow \bar{\nu}_\mu)$$
 - Combining/Comparing measures allows for extraction of core parameters:
 - θ_{13}, θ_{23}
 - δ_{CP} (matter/anti-matter asym in neutrinos)
 - $\text{sign}(\Delta m^2_{31})$ (Mass Hierarchy)
 - θ_{23} octant (flavor coupling μ vs. τ)
 - The large value of θ_{13} greatly improves NOvA's sensitivities
 - Among current (and near future) experiments, NOvA is uniquely able to make these measurements





ν_e Appearance





NOvA Focus



Far Detector Constr./Ops

- Far det. Construction under way.
 - Delayed start (~2 months)
 - Est. Block 0 finished Sept 5th
- Far Det. Calibration data taking will start after full instrumentation of first two blocks
 - Est Nov/Dec 2012
- Computing infrastructure must be in “production” prior to this

Offline Data Analysis

- Significant ramp up in offline activity
- Formation of specific analysis groups (ν_e, ν_μ -CC, exotics, beams, etc...)
- Mock Data challenge under way
- Goal to have first analyses ready 6-8 months after resumption of beam (Winter 2014 conferences)
- $\approx 3\sigma$ significance for the ν_e ($\approx 5\sigma$ after 1 year)



SCD NOvA Projects

OFFLINE/COMPUTING PROJECTS



NOvA/IF Projects

Current Projects

- CernVM File System (NOvA)
- IFBeam Data Services
- FIFE Mon
- Nova-Jobsub
- SAMWeb
- DH-ART Integration
- FTS for Offline

Future Projects

- Offline validation system
- Offline build system revamp
- SAMFS



CernVM File System (CVMFS)



- Purpose:
 - Provide centralized, authoritative software distributions to NOvA computing sites
 - Reduce need for site librarians
 - Allow for NOvA offline to run at offsite facilities
 - Allow for integration of OSG sites with the NOvA job submission framework
 - Simplify NOvA grid jobs packaging
 - Break dependence on Bluearc central disk
 - Reduce overhead associated with NOvA grid jobs
 - Allow for improved efficiency through local caching



CVMFS



- First customer is NOvA
- U.Wisc has provided test CVMFS server for installation of the NOvA analysis suite
- Buy in from SMU for testing/install on their cluster
 - currently have a working NOvA offline distro for their cluster
 - SMU integrated with jobsub (OSG template)
- Target “go-live” date for SMU/CVMFS running 2nd week November
- Goal to have SMU integration be a template for roll out of NOvA software on other OSG sites
- Testing with Fermigrid after proof of concept with SMU



NOvA DBI Revamp



Current DB Interface

- Written by J.Paley (ANL)
- Simple C++ class
- Requires direct connection to DB server
- Does not scale for offline [grid] processing
- Can not handle updates to conditions data and calibrations
- Does not meet NOvA performance requirements

New Interface

- Driven by requirements document generated by NOvA
- Designed by I. Mandrichenko's group
- Web based API with C/C++ bindings and access library
- Indirect DB access (web server front ends) to allow scaling for offline/grid applications
- Intelligent caching for performance
- Based off of IFBeam/Nucondb model



NOvA DBI Revamp

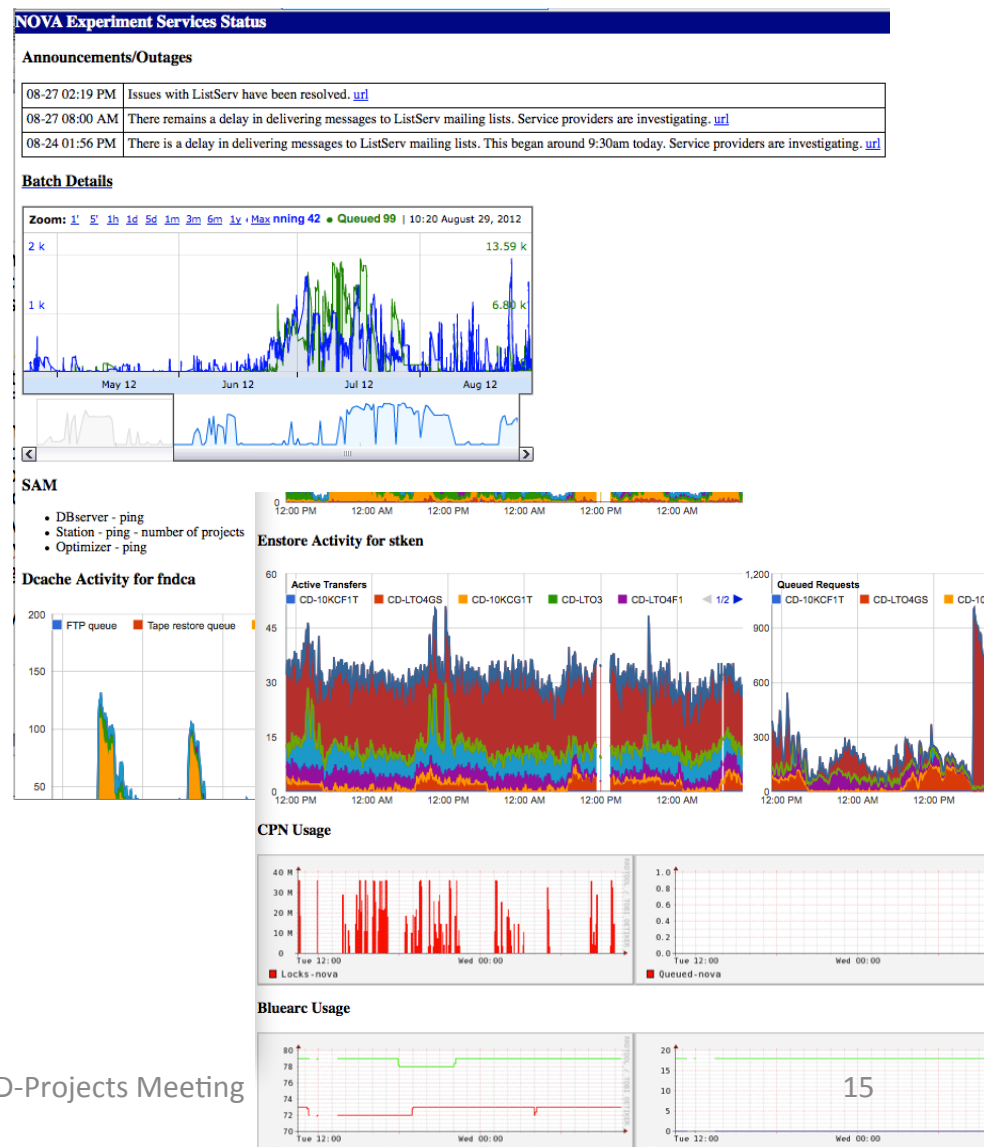


- First draft of requirements generated and reviewed by NOvA collaboration (July)
- Second draft of requirements generated by NOvA DB working group (C.Group, M.Sanchez, A.Norman)
 - Internal review (28AUG)
 - Requirements separate out actual performance requirements from MINOS implementation details
- Target beta release of new DBI October 2012
- Production release targeted for go-live prior to March 2013 production re-processing



FIFE Mon

- Designed to provide at a glance metrics regarding batch processing
- Provides both current and historical information to allow users to observe trends and identify problems
- Currently in testing by NOvA experts for monitoring/diagnosing Monte Carlo production and data reprocessing
- Improvements being suggested by NOvA offline production managers
- See: <https://fifemon.fnal.gov/>





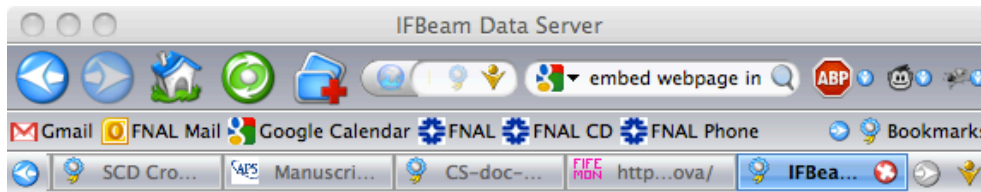
IFBeams DB



- Purpose:
 - Provide a high reliability service for collecting NuMI, Booster operational parameters
 - Operate in experimenter space (i.e. outside the ACNET firewalls and network)
 - Provide pseudo-realtime response for control room monitoring
 - Provide long term database for offline analysis
 - Be independent of MINOS and MiniBooNE offline frameworks
- Status
 - 2011/2012 data being validated against MINOS system
 - Preparing for full production use during 2013 NuMI run



IFBeams



IF Beam Data Server

[Home](#) | [Data](#) | [Dashboard](#) | [Monitor](#) | [A9 Monitor](#) | [DB Status](#) | [Browser](#) | [Bundles](#) | [Login](#)

☒ Auto-refresh

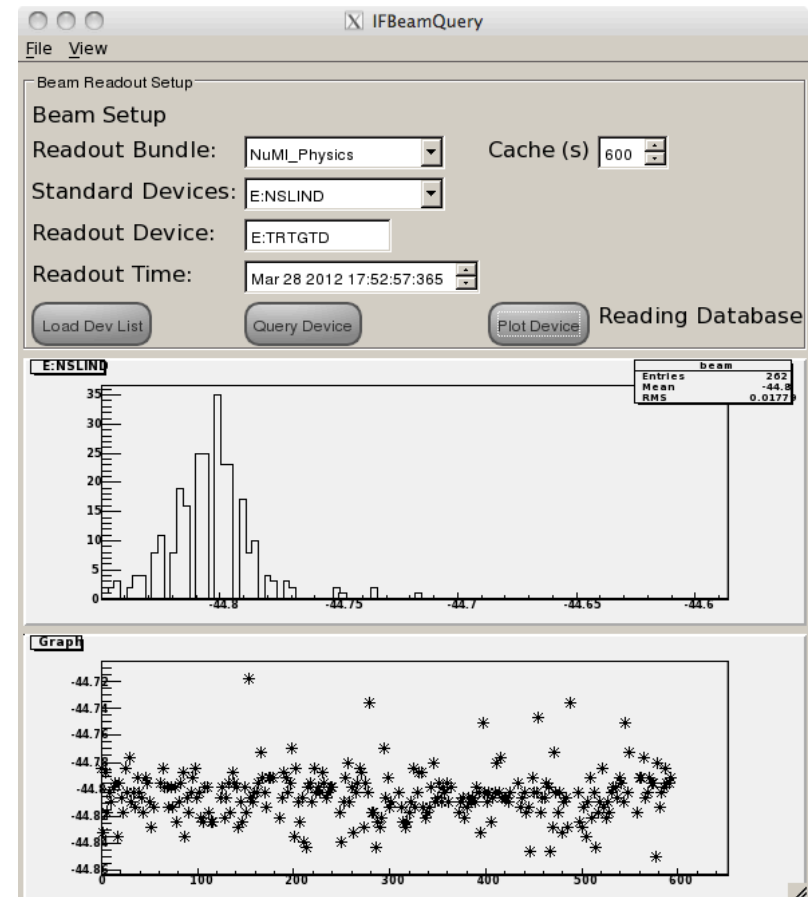
Event	Timestamp	Interval	Fast avg	Slow avg
e,8f	2012-08-28 18:01:20.000 (0.55 sec ago)	1	1	1
e,a9	2012-08-28 18:01:18.025 (2.29 sec ago)	3	3	2.93
p,5000	2012-08-28 18:01:19.093 (0.61 sec ago)	5	5	5

Version: v3_0

Find: figure Next Previous Highlight all Match case

Web Based Interface for control room monitoring needs

8/29/12



C/C++ software API for offline analysis and custom applications

17